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Key Results from the Oriented Scintillation Spectrometer Experiment

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Abstract. Key results obtained by the OSSE instrument during the first four years of the Compton Gamma Ray Observatory mission are presented. OSSE has undertaken extended observations of the gamma ray emission from the galactic center region and found the positron annihilation radiation to be consistent with a two-component model: a spheroidal component located at the galactic center and a weaker galactic disk component. Simultaneous observations with the SIGMA imaging instrument have provided the first low-energy gamma ray spectrum of the diffuse continuum emission from the galactic center region. Results on galactic sources include the spectral observations of two new rotation-powered pulsars, PSR 1509-58 and Vela, the discovery of 110 keV cyclotron emission from the Be X-ray binary A0535+26, and the discovery that galactic black hole transients have two spectral classes: thermal and power-law. Extragalactic sources also have two spectral classes. Seyfert galaxies are typified by thermal spectral with exponential cutoffs from 50-300 keV, and blazars which exhibit power-law spectra that extend into the EGRET energy range. Blazar spectra also often have a spectral break in the MeV region. OSSE has also obtained several observations of supernovae, including the first detection of ^{57}Co from SN 1987A, hard X-ray emission from a shock-heated pre-SN wind in SN 1993J, and upper limits for ^{44}Ti and ^{56}Co emission from Cas A and SN 1991T resp. Finally, recent observations to confirm the COMPTEL observation of 4.4 and 6.1 MeV line emission from the Orion region have provided only upper limits, thereby placing constraints on the intensity and/or distribution of the emission.

Key words: Gamma rays: observations, The Galaxy: center, Stars: neutron, Galaxies: active, Stars: supernovae: general, Stars: binaries: general

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1. Introduction

At this 3rd COMPTON Symposium, over four years after the launch of the COMPTON Gamma Ray Observatory (CGRO), it is appropriate to review the original goals of the several instruments and assess the progress we have made toward achieving those goals. It is worth noting that those goals were established when the GRO instruments were proposed over 17 years ago! The OSSE objectives included broad goals in the areas of: supernovae, novae, neutron stars, galactic black hole candidates, pulsars, diffuse galactic emissions, cosmic ray interactions with the ISM, Seyfert galaxies, quasars, solar flares, and cosmic gamma ray bursts. The overall objectives have not evolved very much in the intervening period as low-energy gamma ray astronomy has made steady progress with the results from several missions including the HEAO-C1, SMM and SIGMA gamma ray spectrometers and the substantial progress made with advanced balloon-borne instruments. OSSE has contributed to the field through its significant improvement in sensitivity relative to earlier instruments. This paper summarizes key results that have been obtained with OSSE. A more detailed description of many of these results are presented elsewhere in this volume.

2. Galactic Center Region

Extensive observations of the galactic center region have been undertaken during the first several years of the CGRO mission. The objectives of these observations include mapping the distribution of the 0.511 MeV and positron annihilation continuum emissions, mapping the diffuse galactic continuum emission, searching for evidence of a variable point source(s) of 0.511 MeV emission, and the detection and study of other discrete sources. Purcell

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et al. (1993a, 1993b, 1994) discuss the galactic center observations. Briefly, the 0.511 MeV emission is adequately described by two components. The more intense component, with an intensity of 1.5 x 10^{-3} γ $cm^{-2}s^{-1}$ in the inner radian is a spheroid centered on the galactic center and with scale size of about 1.2 kpc. There is also a narrow disk component that is observed out to $\sim 40°$ galactic longitude, but whose intensity at the galactic center is only $\sim$20% that of the spheroidal component. Kinzer et al. (1995; these proceedings) find the positron continuum distribution is consistent with the 0.511 MeV line emission, with a positronium fraction of 0.97$\pm$0.03. No contribution from a discrete source of 0.511 MeV emission is required. The upper limit for steady 0.511 MeV emission from 1E 1740.7-2942 is $\sim 10^{-4}$ γ $cm^{-2}s^{-1}$. Future work is aimed at producing maps of the galactic center region to facilitate improved modeling of the origin of the positrons through correlations with the several candidate sources (novae, supernovae, pulsars, black holes).

Several correlative observations have been undertaken with the imaging SIGMA experiment (Cordier et al. 1994) to extract the diffuse and discrete components in the galactic center region. For the first time, the continuum spectrum of the central region of our Galaxy, from which the contributions of the stronger discrete sources have been removed, has been obtained (Purcell et al., 1995; these proceedings). Fig. **??** shows a preliminary spectrum of the

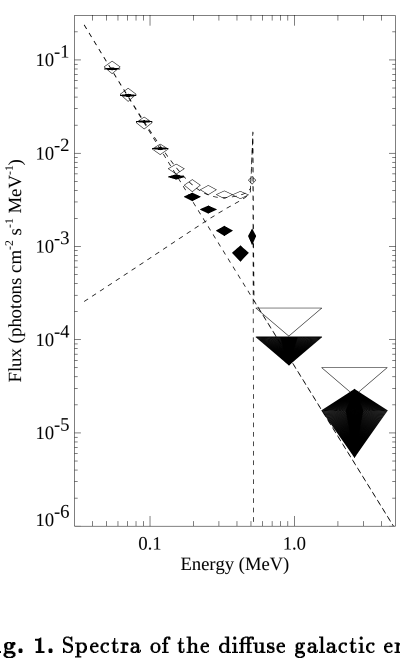

Fig. 1. Spectra of the diffuse galactic emission at $l = 0°$ (open diamonds) and at $l = 25°$ and 339° (filled diamonds). The dashed curves represent a fit to the galactic center spectrum, including a power law continuum, an annihilation line, and positronium continuum.

diffuse flux from the galactic center with the long axis of the OSSE collimator parallel to the galactic plane. For comparison, the average spectrum at galactic longitudes 25° and 339° is also shown. The continuum emissions for the two spectra are very similar. The main difference is the increased flux of 0.511 MeV and associated positronium continuum emission from the galactic center region. The continuum emission is extended in galactic longitude, similar to that seen in high-energy gamma rays. Combining these results with Ginga and COMPTEL data, Skibo et al. (1995; these proceedings) find that, assuming the low-energy gamma ray emission is electron bremsstrahlung, the power input is an order of magnitude larger than that provided by galactic supernovae. They suggest that the energy is derived from large scale kinetic motions of the spiral structure of the Galaxy. Alternately, unresolved discrete sources might account for the emission.

3. Galactic Sources

OSSE has undertaken observations of many galactic sources, including pulsars, neutron stars in accreting binary systems, and black hole candidates. Many of theses have been as targets of opportunity following detection of an outburst by BATSE or by the WATCH transient monitor on GRANAT.

3.1. Rotation-powered pulsars

Prior to GRO, the Crab Pulsar, PSR 0532+22 was the only rotation-powered pulsar detected at hard X-ray energies and the Crab and Vela pulsars were the only pulsars detected above 100 MeV. With the launch of CGRO, the number of known gamma-ray emitting spin-powered pulsars has increased from two to seven (Crab, Vela, PSR B1509-58, PSR B1706-44, PSR B1055-52, PSR B1951+32, and Geminga), the first three of which have been detected by OSSE. Results from the Crab pulsar and PSR B1509-58 have appeared elsewhere (Ulmer et al. 1994, Matz et al. 1995, respectively).

OSSE has recently reported the first detection of low-energy gamma ray emission from the Vela pulsar (Strickman et al. 1995) in the 70–600 keV band. A double-peaked pulse profile similar to that observed at higher energies is seen The OSSE spectrum is quite hard, with a best-fit photon power law index of -1.3. Combined with higher energy data from COMPTEL and EGRET, the spectrum appears to require a break near 20 MeV. Strickman et al. (1995) have also reported upper limits to the hard X-ray emission from GEMINGA where a spectral break in the MeV region is also indicated.

3.2. Neutron Stars in Binary Systems

OSSE has observed significant hard X-ray emission from at least six neutron-star + Be-star binary systems: A0535+26, 4U 0115+63, GRO J1008-57, 2S 1417-624, X

Per, and PSR B1259-63. Be binary systems are known to be transient hard X-ray emitters, with the increased emission usually interpreted as episodic mass transfer to the neutron star from the Be companion. The hard X-ray spectra of these accretion-powered sources are usually thermal, with characteristic temperature kT ~20 keV, and with luminosity peaking well below the OSSE threshold of ~45 keV. With the exception of PSR B1259-63 discussed below), OSSE has observed soft thermal spectra above 50 keV (Grove et al. 1995b) and clear pulsations at the spin periods of these neutron stars.

A0535+26 is a high mass X-ray binary which has a recurrent, transient pulsar with a pulse period of 103 s. Kendziorra et al. (1994), reporting on results obtained with the HEXE instrument on Mir, suggested evidence for cyclotron absorption features at 50 and 100 keV. OSSE observed A0535+26 during an unusually intense outburst from 8-17 Feb 1994. Figure ?? shows the phase-averaged spectrum summed over the entire OSSE observation. The spectrum shows a clear deficit near 100 keV which demands spectral features or multi-component spectra to adequately characterize the emission. Grove et al. (1995a) find that the best fit is obtained with an absorption feature at 110 keV. The optical depth of the feature is large (τ = 1.8) as seen in Fig. 2c. The OSSE data for the phase-averaged spectrum is consistent with no absorption feature at 55 keV; however, the lower limit of the OSSE energy range (45 keV) makes a definitive statement about a 55 keV line difficult. If the fundamental is at 110 keV, this implies a surface magnetic field of 1.1 x 10^{13} gauss, the most intense for an accreting source.

The exception among the Be binary systems studied by OSSE is PSR B1259-63. This system contains a 48-ms radio pulsar with spin-down luminosity ~ 9 x 10^{35} ergs s^{-1} in a highly elliptical orbit with period ~ 3.4 yr. The coherent radio pulsations are lost near periastron when the neutron star enters the region dominated by its dense equatorial outflow from the Be star. For the first time, the interaction of a relativistic pulsar wind and a mass outflow from a Be star can be studied in a time-variable environment. OSSE observed PSR B1259-63 for a 3-week period in January 1994 chosen to cover the periastron passage (Grove et al. 1995c). During this same period, ASCA made three short observations (Kaspi et al. 1995). OSSE detected emission from 50 keV to 200 keV at a level of 5 mCrab (total) flux units. The combined OSSE and ASCA spectrum is consistent with a single power law over 2-200 keV with photon index ~ 1.9 and suggests that the emission is shock-powered rather than accretion-powered, although the precise nature of the shock process is open to debate. Tavani & Arons (1995) have suggested that the emission may result from synchrotron cooling of relativistic particles from the pulsar wind, which shocks when it meets the wind from the Be star.

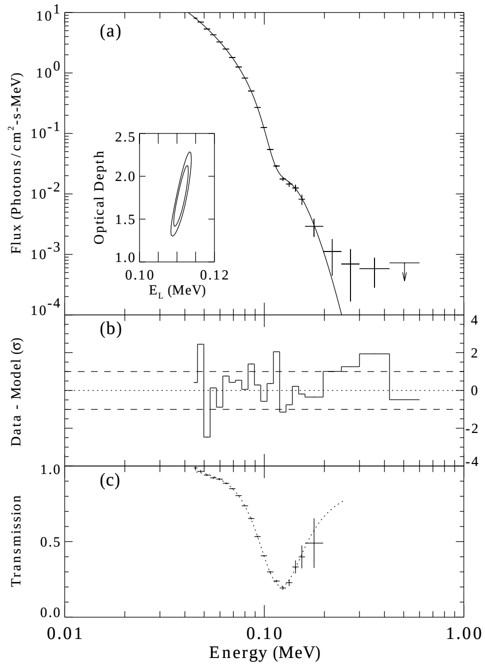

Fig. 2. (a) Photon spectrum for A0535+26. The best-fit model is a power law times an exponential with an absorption line at 110 keV. (b) Residuals from the best fit. (c) Transmission function for the absorption line feature.

3.3. Cygnus X–1

OSSE has observed Cyg X–1 on more than 120 days (Phlips et al. 1995). The OSSE data in the 45-140 keV energy range show gradual intensity changes but no well-defined intensity levels, similar to the $\gamma 1$, $\gamma 2$, and $\gamma 3$ states suggested by Ling et al. (1987) The luminosity has varied over more than an order of magnitude, including reaching a new low, $\approx$ 20% of the historic $\gamma 1$ low state. Emission is detected up to nearly 1 MeV, with a spectrum that is consistent with thermal Comptonization in an optically thin medium, with no compelling evidence for reflection. A single-temperature, optically-thick thermal Comptonization model (Sunyaev & Titarchuk 1980) is not an acceptable fit, significantly underestimating the observed flux above ~200 keV. Many of the OSSE observations have been at intensity levels which are similar to the HEAO-C1 level, when Ling et al. (1987) suggested an "MeV bump" was present. OSSE sees no evidence for excess emission near 1 MeV at any luminosity: The distribution of daily "MeV bump" amplitudes has a FWHM of ~10% of the flux reported by Ling et al. (1987), while the 90% confidence upper limit for the sum of all days is ~40 times lower than Ling's value. Cyg X–1 does appear to exhibit temperature-intensity correlations, wherein episodes of lower effective temperature of the emission are observed

as the overall X-ray luminosity is reduced. This correlation is shown in Figure ??.

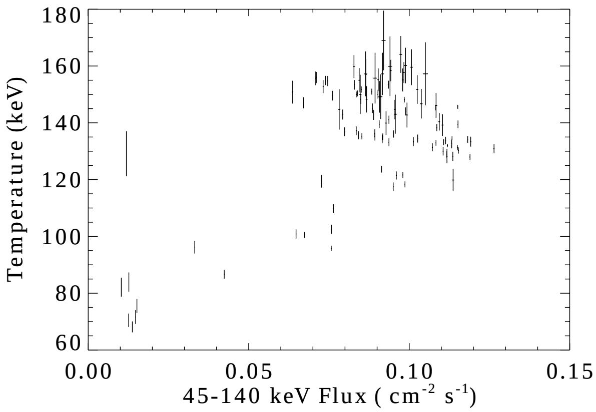

Fig. 3. Correlation between the exponential folding energy with the 45–140 keV flux for Cyg X–1. Each data point corresponds to a single day.

3.4. X-ray Novae

OSSE has observed four X-ray novae: GRO J0422+32 (XN Per 1992), GRS 1716–249 (XN Oph 1993), GRO J1009–45 (XN Vel 1993), and GRO J1655–40 (XN Sco 1994). Two gamma ray spectral classes are readily apparent: The first two objects show exponentially cut off thermal spectra (similar to the spectra of the persistent emitters Cyg X–1 and GX339–4), while the latter two have fairly soft power law spectra

OSSE observed GRO J0422+32 in Aug-Sep 1992, at the peak of an intense outburst (Kroeger et al. 1996). The OSSE spectrum alone is reasonably well fit by a simple thermal bremsstrahlung model with characteristic temperature kT ~100 keV, and with emission detected up to ~600 keV. The average spectrum from 5 days shortly after the peak is shown in Figure ??, together a contemporaneous spectrum from TTM and HEXE on Mir (M. Maisack, private communication). The spectrum is plotted as $E^2 \times$ flux and shows that the luminosity per energy decade is fairly strongly peaked near 100 keV. The combined spectrum can be described by an exponentially truncated power law, which is a good approximation to the emergent spectrum from thermal Comptonization in an optically thin medium (Haardt et al. 1993). The hard X-ray photon index is -1.5, the break energy 70 keV, and the exponential folding energy 130 keV. As with Cyg X–1, the optically-thick thermal Comptonization model of Sunyaev & Titarchuk (1980) can be ruled out.

Independent fits to daily spectra with a thermal bremsstrahlung functional form indicate a gradual hardening of the spectrum–i.e. an increase in the folding energy, kT, as the luminosity decreases. Indeed, as shown in Fig. ??, a nearly linear anti-correlation exists between the temperature and flux at 100 keV. Note that this behavior is dramatically different from the temperature-flux relationship observed in Cyg X-1.

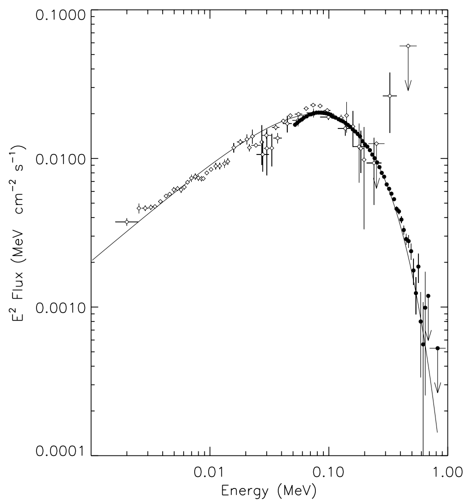

Fig. 4. Combined TTM, HEXE, and OSSE (filled circles) spectrum from GRO J0422+32, along with best-fit exponentially truncated power law. Spectra are plotted as $E^2 \times$ flux, i.e. luminosity per energy decade.

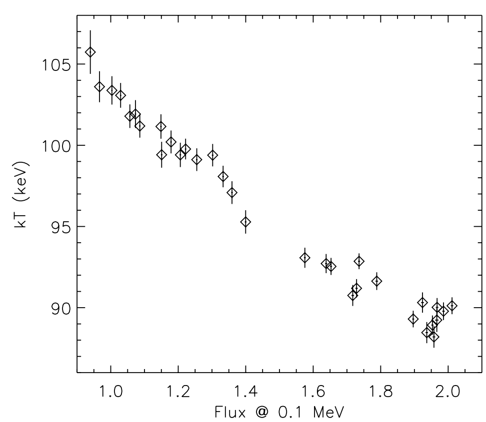

Fig. 5. Anti-correlation between flux at 100 keV and thermal bremsstrahlung temperature for GRO J0422+32. Flux units are photons cm^{-2} s^{-1} MeV^{-1}.

The X-ray nova GRO J1655-40 has undergone several strong outbursts since its discovery in August 1994 and

is shown to have highly relativistic radio jets (Hjellming & Rupin 1995). Several target of opportunity observations have been performed by OSSE and reported by Kroeger et al. (1995; these proceedings) The total spectrum (Fig. ??) from 10 days of data shows no evidence for a thermal cutoff and is consistent with a single power law. Note also that the photon power law index of -2.6 is substantially softer than that observed below 50 keV in GRO J0422+32, and because of the steepness of the spectrum, the luminosity per energy decade peaks somewhere below 50 keV.

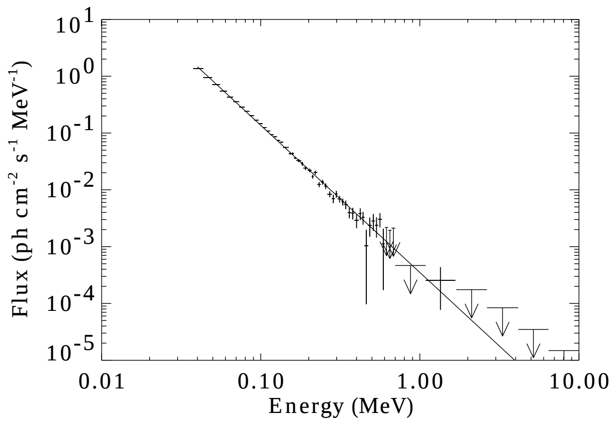

Fig. 6. Spectrum of GRO J1655–40 from 10 days of observation. Best fit photon index is , = 2.6.

3.5. 1E 1740.7-2942

1E 1740.7-2942 is a variable hard X-ray source about 1° from the galactic center with radio jets emanating from the location of the X–ray source (Mirabel et al. 1991). SIGMA has reported several episodes of enhanced emission above 200 keV which have been interpreted as redshifted positron annihilation radiation. The most compelling evidence occurred on 13-14 Oct 1990 (Bouchet et al. 1991). A similar 1-day transient, but of lower significance, occurred on 20-21 Sept 1992 (Cordier et al. 1993). This unusual character led to speculation that it may be the source of variable 0.511 MeV positron annihilation radiation which has been reported from the galactic center region (Riegler et al. 1985; Leventhal et al. 1989). Ramaty et al. (1992) suggest a model wherein outbursts of 1E 1740.7-2942 produce electron-positron pairs near a black hole. Some of the positrons annihilate on local material and produce the broad and gravitationally red-shifted emission seen by SIGMA. The remainder form part of the jet and eventually annihilate in a nearby molecular cloud (Bally and Leventhal 1991) producing the narrow 0.511 MeV line.

OSSE also has observations for the 1-day event of 20-21 Sept 1992. Jung et al. (1995) do not confirm an excess emission above 200 keV in the OSSE spectrum shown in Figure ??. For the reported SIGMA flux, OSSE should have seen a 5-13σ increase, but did not. Smith et al. (1994) using BATSE data also failed to confirm a SIGMA report of enhanced γ–ray emission in October, 1991. These, coupled with the lack of variability in the 0.511 MeV emission from the galactic center region in ~200 days of OSSE observations (Purcell et al. 1994), and the lack of evidence for SIGMA-like events in the SMM data (Harris et al. 1995), suggests that the case for pair production associated with galactic black hole candidates remains open.

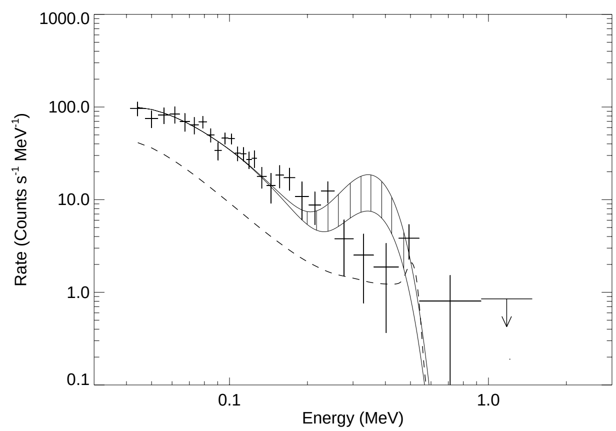

Fig. 7. OSSE (data points) and SIGMA (hatched) spectra for 1E 1740.7-2942 on Sept. 20-21, 1992. The dashed line is the estimated contribution of the diffuse galactic emission to the OSSE spectrum.

4. Active Galaxies

Prior to the launch of CGRO, based primarily on a limited sample of balloon observations, it was generally expected that active galaxies of all classes would exhibit similar hard spectra up to several MeV before breaking to softer spectral indices. CGRO observations have dramatically changed that picture. Two spectral classes have emerged: The first, generally associated with the Seyfert galaxies, has spectra that break sharply in the ~50–300 keV range, while the second, generally associated with BL Lacs, highly polarized, and optically violently variable quasars, has relatively hard spectra extending to GeV and beyond.

4.1. Seyfert Galaxies

Maisack et al. (1982) measured the spectrum of the nearby Seyfert galaxy NGC 4151 and were surprised to find a

thermal-like spectrum rather than the power-law suggested by an early balloon experiment (Perotti et al. 1981) Johnson et al. (1994) subsequently reported the average spectrum for Seyfert galaxies by summing the spectra of a number of weak Seyferts observed by OSSE during the first years of the mission. The average spectrum, shown in Figure **??**, is significantly softer than the typical photon power law index, , ~1.7, observed in X-rays (Rothschild et al. 1983) and is best described by a simple exponential function with an e-folding energy of 45 keV. The canonical Seyfert spectrum must therefore break somewhere in the 50-300 keV range, and supports the idea that Seyferts are the dominant source of the low-energy cosmic diffuse γ–ray background.

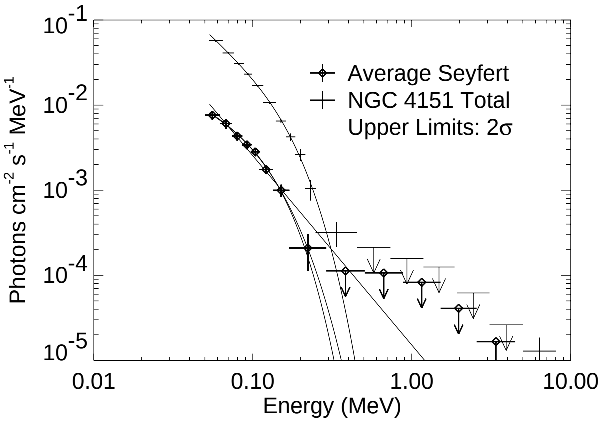

Fig. 8. The average spectrum of weak Seyfert galaxies, along with exponential and power law models. The spectrum of NGC 4151 is also shown.

Zdziarski et al. (1995) have extended this work, obtaining the first average 2-500 keV spectrum of Seyfert galaxies, by combining Ginga and OSSE data from nine objects: radio-quiet Seyfert 1s and 2s, and radio-loud Seyfert 1s. The average radio-quiet Seyfert 1 spectrum is described by a power law continuum with photon index ~1.9, a Compton reflection component corresponding to a $\sim 2\pi$ covering solid angle, and ionized absorption. The power law continuum cuts off with an e-folding energy of 500 keV. This spectral shape is consistent with a Comptonization model in a relativistic optically thin thermal corona above the surface of an accretion disk. Radio-quiet Seyfert 2s show strong neutral absorption and some evidence for intrinsically harder power laws. Radio-loud Seyferts show little or no Compton reflection, which Zdziarski et al. (1995) interpret to indicate that the X-rays are beamed away from the accretion disk.

4.2. Blazars

One of the significant surprises of the CGRO mission is the discovery by EGRET of a new class of energetic sources, the gamma-ray emitting blazars (Fichtel et al. 1994). The detectability and spectral shape of these objects in the low-energy gamma ray band covered by OSSE bears on the several candidate emission mechanisms. Of the ~45 high-confidence EGRET detections of blazars, OSSE has observed 13 and detected 9, namely 3C 273, 3C 279, PKS 0528+134, CTA 102, QSO 2251+158, PKS 2155–304, PKS 0506–612, NRAO 140, and PKS 1622–297 (McNaron-Brown et al. 1995). In addition, OSSE has detected the BL Lac H1517+65.6, which has not (yet) been detected by EGRET. In general the OSSE detections and upper limits require that blazar spectra break somewhere between 1 MeV and 30 MeV, with break amplitudes as large as $\Delta,\ = 1.5$. Figure **??** shows combined OSSE, COMPTEL, and EGRET spectra for five blazars. Note however that only the 3C 273 observations are simultaneous, where the spectral break is $\Delta,\ \approx 0.7$. The combined CGRO spectra are providing substantial challenges to our theoretical understanding of the emission mechanisms in AGN: spectral breaks significantly in excess of 0.5 are in conflict with both simple Compton cooling jet models (e.g. Dermer & Schlickeiser 1993; Sikora, Begelman, & Rees 1993) and synchrotron self-Compton models (e.g. Maraschi, Ghisellini, & Celloti 1992).

McNaron-Brown et al. (1995) also showed that the OSSE data provide strong evidence for beamed gamma ray emission from blazars, based on gamma ray transparency arguments.

4.3. Centaurus A

The nearby radio galaxy Centaurus A may represent an intermediate spectral class between the Seyfert galaxies and blazars. Cen A, at a distance of 3.2 Mpc, is the nearest active galaxy. Kinzer et al. (1995) have reported on several OSSE observations of Cen A. They find that it exhibits the fastest gamma-ray variability observed for any gamma ray AGN, with 12-24 hr. variations having been observed. The overall spectrum has a break at several hundred keV in the more intense levels as observed by OSSE (which are low compared to historical intensities) and also hardens as the intensity decreases. It is possible that the low-energy gamma ray emission includes both a thermal Seyfert-like component as well as evidence for gamma rays scattered in a jet as suggested by Skibo et al. (1994). The latter may be detectable even though the jet may be inclined at large (70°) angle with respect to the observer, but still detectable since the source is nearby.

5. Supernovae

OSSE has observed several supernovae or supernovae remnants with the primary objective of testing models for

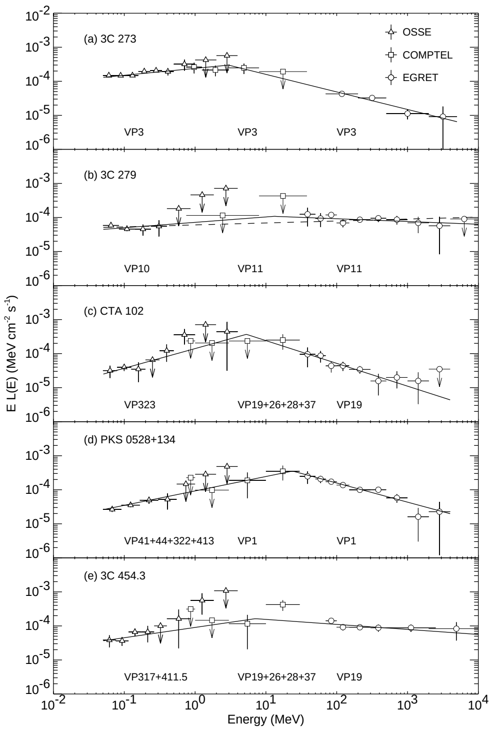

Fig. 9. OSSE, COMPTEL, and EGRET spectra of five blazars, displayed as $E^2\times$ flux, along with best-fit broken power law models. Only the 3C 273 observation is simultaneous.

heavy element nucleosynthesis. OSSE observations of SN 1987A provided the first detection of ^{57}Co $\gamma-$rays (Kurfess et al. 1992). These data constrained the late time energy input into the supernova remnant and, coupled with the previous observations of ^{56}Co, the nucleosynthetic processes in Type II supernovae (Clayton et al. 1992).

SN 1991T, a Type Ia supernovae in NGC 4527, was observed early in the mission. At a distance of 13 Mpc, A marginal detection of ^{56}Co has been reported by Morris et al. (1995) with the flux of the 847 keV emission at a level of 5.3 x 10^{-5} γ cm^{-2}s^{-1}. OSSE does not detect the ^{56}Co emission (Leising et al. 1995). The OSSE data, are in agreement with previous COMPTEL limits (Lichti et al. 1994) and appear to rule out those models for Type 1a supernovae which produce close to 1 $M_\odot$ of ^{56}Ni.

An important objective of low-energy gamma ray astronomy is to use observations of ^{44}Ti decay gamma rays to search for recent supernovae in the Galaxy. The decay of ^{44}Ti produces gamma ray lines at 68, 78 and 1156 keV. ^{44}Ti is therefore a tracer of nearby galactic supernovae that may have occurred in the past several hundred years, but that otherwise may have gone undetected. Recently, the COMPTEL team (Iyudin et al. 1994) has reported the detection of ^{44}Ti ($\tau_{1/2}$= 46.4 - 66.6 yrs) in the supernova remnant Cassiopeia A by the observation of 1.156 MeV gamma rays at a flux of 7.0$\pm$1.7 x 10^{-5} γ cm^{-2}s^{-1}. At a distance of 2.8$\pm$ 0.2 kpc, the COMPTEL observation implies the production of 1.5–3 x 10^{-4} $M_\odot$ of ^{44}Ti, at the upper end of the expected range for Type II (core collapse) supernova.

OSSE observed Cas A for a period of three weeks during 1992. Analysis of the OSSE data has been undertaken (The et al. 1994) by jointly fitting the OSSE spectrum for the three ^{44}Ti decay lines at 68, 78 and 1156 keV. They reported a 3σ upper limit for each of these lines of $\sim$6 x 10^{-5} γ cm^{-2}s^{-1}. This result was in marginal disagreement with the COMPTEL result.

Observations in May 1995 have recently been completed in an attempt to resolve the discrepancy. The OSSE result obtained when all of the Cas A observations are combined is reported by The et al. (these proceedings). Fitting the summed spectrum of all OSSE observations yields a flux of 1.7$\pm$1.5 x 10^{-5} γ cm^{-2}s^{-1} in each of the three ^{44}Ti lines. Revised COMPTEL results reported at this meeting have reduced their observed flux of the 1156 keV line to 4.2$\pm$0.9 x 10^{-5} γ cm^{-2}s^{-1}. Thus OSSE and COMPTEL still appear to be in marginal disagreement although the flux of ^{44}Ti gamma ray is likely to be substantially lower than the earlier COMPTEL report and also less demanding on models for ^{44}Ti production in Type II supernovae.

Gamma radiation from a Type II supernova at the distance of M81 (3.6 Mpc) would not be expected to be detectable by GRO. However, OSSE did observe hard X-radiation from SN 1993J following the explosion in March 1993 (Leising et al. 1994). Enhanced emission was observed in the periods 10-15 and 24-37 days after the explosion with an $\sim$E$^{-2.2}$ spectrum. This emission is not due to scattered nuclear line gamma radiation which would have a much harder spectrum below 100 keV. The radiation observed by OSSE is believed to arise from matter in the pre-supernova stellar wind which is heated by the supernova shock to temperatures of $\sim$10^9 K.

De Jager et al. (1995) have also discovered emission from the Vela supernova remnant with a rather hard spectrum that is consistent with an extrapolation of the E$^{-1.7}$ spectrum of the 1 arcmin radius compact nebula seen between optical and 25 keV with imaging instruments. They conclude that the accelerated electrons responsible for the emission in the OSSE band (i.e. up to at least 400 keV) must escape from the compact nebula and travel to large distances, losing their energy to the radio synchroton emission that powers the extended nebula.

6. MeV line emission from Orion

Bloemen et al. (1993) have reported the discovery of line gamma ray emission in the 4-7 MeV energy range from the region of Orion. This emission is assumed to result from energetic interactions of material with high abundances of

^{12}C and ^{16}O. OSSE has searched the Orion region for evidence of the gamma ray line emission reported by COMPTEL during several viewing periods in Cycle 4. (April 4-11, 1995 and May 9 - June 6, 1995). With the OSSE field of view of 3.8° x 11.4° and the offset background pointing mode of operation, it is not possible to optimize the observations to a very large scale emission. Therefore, viewing strategies were adopted which provided good sensitivity if the emission originated from relatively localized regions, in particular the molecular cloud regions Orion A and Orion B which are separated by about $\sim$4°. Background fields were chosen far enough removed so as to eliminate any contributions from the emission region suggested by the COMPTEL contours. At this time, we can only provide preliminary results for our search of MeV emission from the Orion region. These must also be presented based on the assumption of whether the gamma ray lines are narrow or broad, and we also provide a limit the total emission in the 3-7 MeV region. Results of these OSSE observations are in preparation (Share et al. 1996). A preliminary limit to the integrated 3-7 MeV from the OSSE observations is -5.0$\pm$4.1 x 10^{-5} γ cm^{-2}s^{-1}. This compares with a COMPTEL flux of 9.0$\pm$ 2.1 γ cm^{-2}s^{-1} in the 4-7 MeV region. It must be emphasized that this OSSE limit applies to concentrated emission from the Orion A and Orion B region. This suggests that if the COMPTEL detection reflects line emission from Orion, the emission is extended on a scale comparable to or larger than the OSSE field of view or that the location of the emission is unlikely to be associated with localized regions such as Orion A or Orion B or the immediate region between theses clouds.

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